Wind Turbine Calculations and Validation

Robert M. Kufeld

The computation of the aerodynamic performance, flow separation, and dynamic stall on a rotating wing or blade continues to challenge the rotorcraft designer. Compressibility, stall delay, rapid change of angle of attack, dynamic stall, wake interaction, and flow unsteadiness are problems unique to rotors. Extensive research and testing to improve the calculations have been conducted over the years to help solve these problems as they relate to rotorcraft. This past year a partnership was initiated between the National Renewable Energy Laboratory and Ames to apply computational fluid dynamics (CFD) and comprehensive computation tools developed for rotorcraft to the study of wind turbines.

CFD performance calculations (see fig. 1) were made of a research horizontal-axis wind turbine (HAWT) using a compressible Reynolds-averaged Navier–Stokes equations code using overset grids (OVERFLOW code version 1.6ap-rotorcraft) and a comprehensive vortex lattice method code (CAMRAD II). The results were compared with measurements collected during a full-scale wind tunnel test of

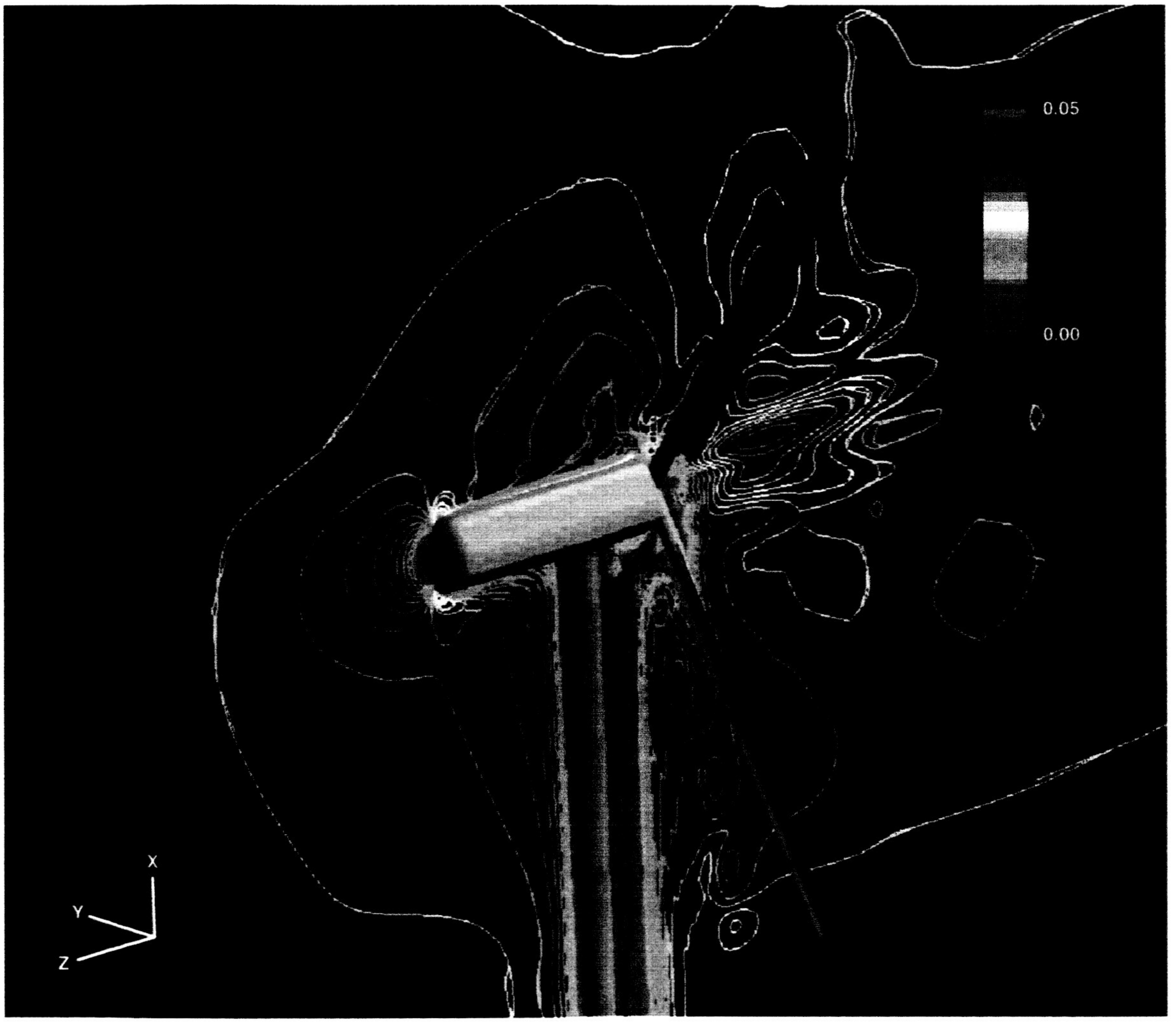

Fig. 1. Velocity contours for the complete rotor-tower-nacelle configuration as calculated by OVERFLOW.

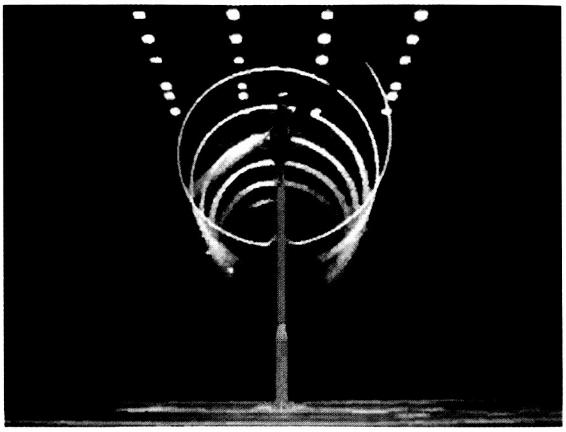

Fig. 2. The research wind turbine inside the 80- by 120-Foot Wind Tunnel expelling smoke for wake visualization; airspeed = 7 m/sec, blade pitch = 3 degrees, yaw angle = 0.0 degrees.

the research wind turbine in the NASA Ames Full-Scale Aerodynamic Complex (80- by 120-Foot Wind Tunnel) (Fig. 2).

The research wind turbine was 10 meters (m) in diameter, turned at 72 revolutions per minute (rpm), and could generate 20 kilowatts (kW) of power. The turbine was highly instrumented with over 150 pressure transducers, strain gages, and motion sensors to identify its operational state. Easily reconfigured with both blade-pitch and nacelle azimuth control, the research wind turbine was tested in many different operational variations. Nominal testing was at airspeeds between 5 and 25 meters per second (m/sec) with a few test points recorded at 40 m/sec.

Point of Contact R. Kufeld
(650) 604-5664
rkufeld@mail.arc.nasa.gov

Remote Access and Analysis of Aeronautics Data

David Korsmeyer, Joan Walton

The DARWIN system has been developed in conjunction with new computational and experimental test technologies to provide remote access to the integrated knowledge generated from these independent systems. Version 2.5 of the DARWIN system for remote access to and analysis of aeronautics data was completed and deployed at the Ames wind tunnels in December 1999. The new and improved version was used by the Wind Tunnel Operations Division to support one of the first tests in the newly modernized 11- by 11-Foot Transonic Wind Tunnel in early January 2000.

The deployment of DARWIN version 2.5 at the Ames wind tunnels concluded a year of work by the DARWIN development team on implementing enhancements to the DARWIN system. The major new feature of this release is a completely redesigned database schema. Building on 3 years of experience with the original database and on feedback from collaborators at NASA Langley, Eglin Air Force Base, and Arnold Engineering Development Center, the team developed a schema that can store values for a wide range of variables and thus flexibly capture information from disparate wind-tunnel test entries. All components of the DARWIN system, including the client, administrator, and database loader, were completely reworked to take advantage of the new database schema.

In addition to the new database, other features of this release include an improved client user interface and ability to review data from additional tunnel instrumentation suites, such as Video Model Deformation (VMD), Temperature Sensitive Paint (TSP), and Mini Tufts